ADAPTATION POTENTIAL MAPPING (APM)

CRAFT

Climate resilient value chains for improved livelihoods

WAGENINGEN UNIVERSITY & RESEARCH

The Climate Resilient Agribusiness for Tomorrow (CRAFT)project is a multi–country (Kenya, Tanzania, and Uganda) five-year effort implemented by SNV in partnership with Wageningen University and Research (WUR), CGIAR’sResearch Program on Climate Change, Agriculture and FoodSecurity (CCAFS), Agriterra, and Rabo Partnerships. The project is funded by the Netherlands Ministry of Foreign Affairs, covering June 2018 – May 2023.

This report is developed as a part of CRAFT. The report provides an overview of the intended target group of the adaptation potential mapping, underlying methodologies, data, and key findings.

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WHAT IS AN ADAPTATION POTENTIAL MAPPING?

An adaptation potential map is a tool used in assessing the potential effectiveness of the adaptation measures for planning. It is a spatial representation that provides information based on the vulnerability and adaptive capacity of a particular area or region to the impacts of adaptation measures. The map is typically based on various factors such as social, economic, and environmental indicators.

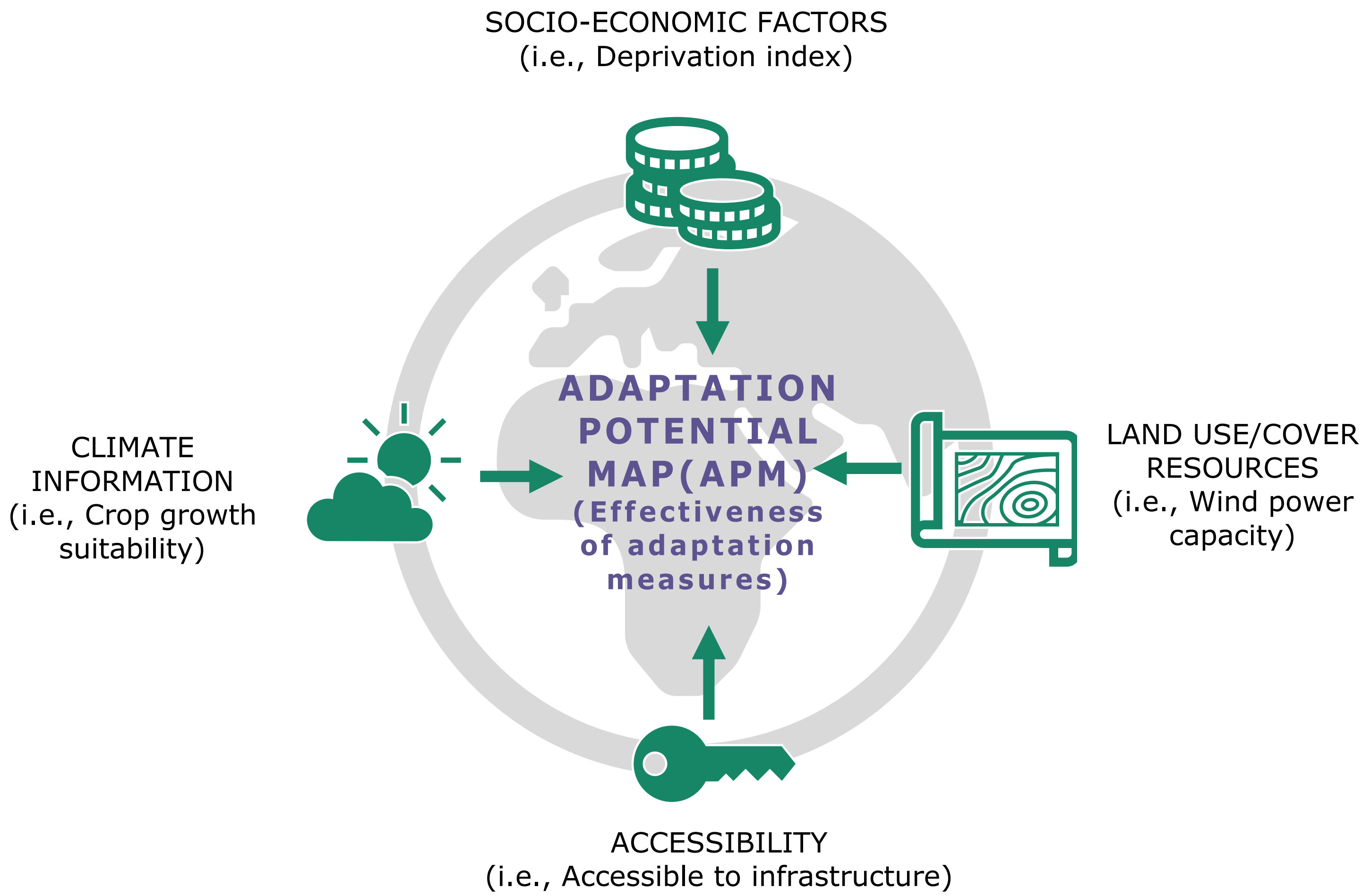

Figure 1. The framework of adaptation potential mapping

WHY DO WE NEED AN ADAPTATION POTENTIAL MAPPING?

Policymakers and practitioners increasingly seek robust evidence on the effectiveness of adaptation measures for climate change mitigation and adaptation.

However, the evidence remains scattered, hindering the adoption and mainstreaming of adaptation measures into adaptation decision-making by value chain actors and policymakers.

A systematic evidence mapping exercise is required to consolidate the large dispersed evidence base on the effectiveness of adaptation measures for addressing climatic impacts.

APM is a systematic mapping exercise that analyzes and map the potential benefits of adaptation measures based on the location-specific resources and constraints classified as two mainstreams, socioeconomic and environmental.

The purpose of an APM is to assist decision-makers/financial institutions in identifying areas that are more effective/not effective in implementing adaptation measures that have a higher potential for successful implementation or to avoid malinvestments in maladaptation.

SCOPE OF AN ADAPTATION POTENTIAL MAPPING

Spatial Analysis and Prioritization

APM was done by spatial analysis, where the effectiveness of adaptation measures is assessed at different geographic scales and user specified locations.

Stakeholder Engagement

APM provides insights on specific adaptation measure to financial institutions to make informed decisions, which encourage targeted investments in regions for potential benefits.

Future scope of adaptation potential mapping

Identifying Adaptation Measures

APM can be involved identifying a range of potential adaptation measures or strategies that can be implemented in response to climate change.

Considering Trade-Offs and Synergies

APM could also examines potential trade-offs and synergies among different adaptation measures via cost benefit analysis.

HOW DO WE DEVELOP AN ADAPTATION POTENTIAL MAP?

A method to develop adaptation potential mapping

Multiple criteria decision analysis (MCDA) has been utilized to derive adaptation potential maps from achieving the scope of the systematic mapping approach. MCDA is a collection of techniques for comparing, ranking, and selecting alternatives using quantifiable or nonquantifiable criteria (Doocy et al., 2013; Mohammadinia et al., 2017).

MCDA has many advantages over informal judgment unsupported by analysis:

(a) It is clear that the choice of objectives and criteria that any decision-making group may make is open to analysis and change if they are deemed inappropriate.

(b) Scores and weights, when used, are also explicit and are developed according to established techniques. They can also be cross-referenced to other sources of information on relative values and amended if necessary.

(c) Performance measurement can be subcontracted to experts, so it need not necessarily be left in the hands of the decision-making body itself.

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MCDA IN ADAPTATION POTENTIAL MAPPING

MCDA applied spatial numerical analysis to a performance matrix in two stages:

1. **Scoring:** the expected consequences of each input considered for adaptation potential mapping are assigned a numerical score on the strength of preference scale for each input criterion.

In practice, scales extending from **1 to 3 (Low, Moderate, and High)** are used, where **1** represents the least preferred option, and **3** is associated with the most preferred option to implement adaptation measures. All input considered in the MCDA would then fall between 1 and 3.

2. **Weighting:** numerical weights are assigned to define, for each criterion (**1 to 3 (Low, Moderate, and High)**), the relative valuations of a shift between the top and bottom of the chosen scale, which covers **100%**.

In practice, the weights have been assigned based on relatively how vital a specific input is to other inputs (i.e., if wind power capacity is more vital than other inputs, a higher weightage would be allocated to wind power capacity). However, weights can be allocated user-specified, and all input weights should be summed up 100%.

Equation 1: Weighted sum calculation to derive adaptation potential

$$\textbf{Adaptation Potential} = \sum_{k=I}^{n} \text{Scoring}(\text{k})\,\text{Weighting}(\text{k})$$

Note: *I = Inputs (APPENDIX) considered for adaptation potential mapping*

STEPS TO DEVELOP AN ADAPTATION POTENTIAL MAP & A SAMPLE CASE

Steps involve:

1. Collection of inputs (APPENDIX) considered for adaptation potential mapping in gridded format.

2. Resampled (a process of converting input to the same scale) all input to a common spatial resolution (~250m), then extracted inputs for CRAFT countries and potato cultivation. Then, for further analysis, reclassified (a process of converting input values) all inputs to the scaling mentioned above.

3. The MCDA (weighted sum based) was applied to the reclassified inputs to derive adaptation potential scores.

	LOW(1)	MODERATE(2)	HIGH(3)	WEIGHTAGE	SCORE
1 Crop Growth Suitability		✓		15%	0.3
2 Photovoltaic Power Potential (PVOUT)		✓		20%	0.4
3 Global Gridded Relative Deprivation Index (GRDI)	✓			10%	0.1
4 Wind Power Density			✓	20%	0.6
5 Distance to the nearest city (Accessibility)	✓			20%	0.2
6 Elevation		✓		15%	0.3
7 HydroBASINS			✓	NA	0.0
Adaptation potential for climate smart warehouse		**MODERATE**		100%	1.9 (2)

Note: Above table is a test case for calculating adaptation potential for climate smart warehouse construction for one location. This method has been applied at spatial scale for one crop (potato) two adaptation measures (climate smart warehouse & irrigation) and three countries (Kenya, Uganda,and Tanzania).

MAP INSIGHTS: WHAT CAN WE LEARN?

Potato in Kenya

- Overall, major potato-growing regions could provide potential benefits in both adaptation measures, irrigation and climate-smart warehouses.

- Uasin Gishu, the Northern part of the Nandi region, and the eastern part of the Bungoma region have a higher potential in climate-smart warehouses than irrigation.

- The southern part of the Nyandarua and a few areas from Nakuru have a higher potential for irrigation than climate-smart houses.

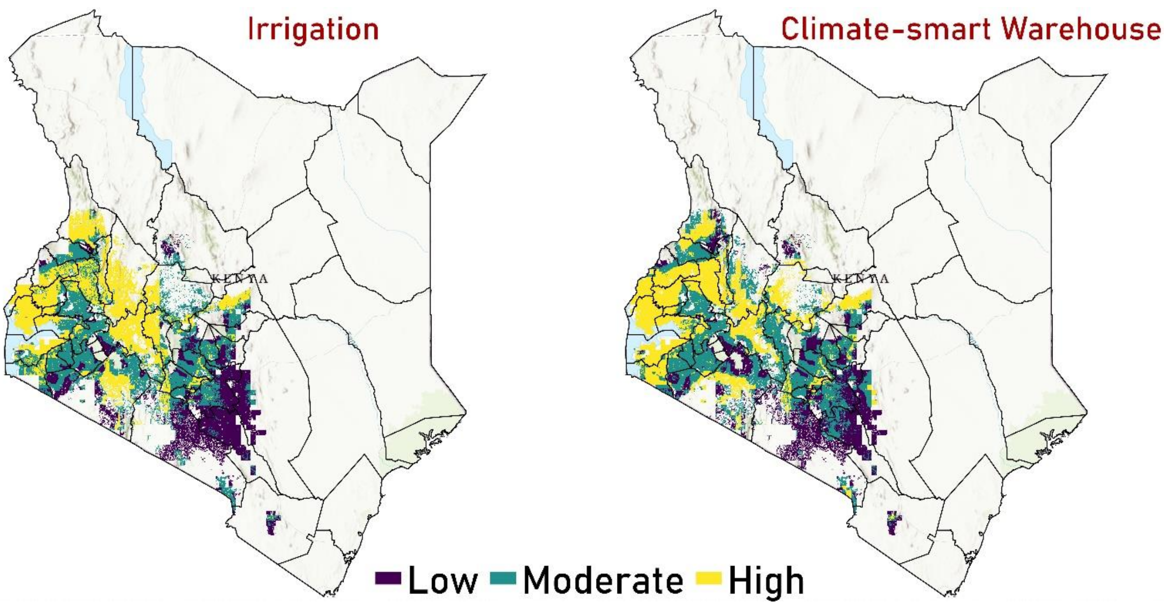

Figure 2. Comparison of the potential of two adaptation measures in potato-growing regions in Kenya under current conditions

MAP INSIGHTS: WHAT CAN WE LEARN?

Potato in Uganda

- Overall, major potato-growing regions in Uganda have a higher potential for irrigation than climate-smart warehouses.
- Significant potato-growing regions Kigezi and Kyenjojo have a higher potential for irrigation than climate-smart warehouses.
- The eastern regions (Mbale, Kapchorwa, and Sironko) have a higher potential for climate-smart houses than irrigation.

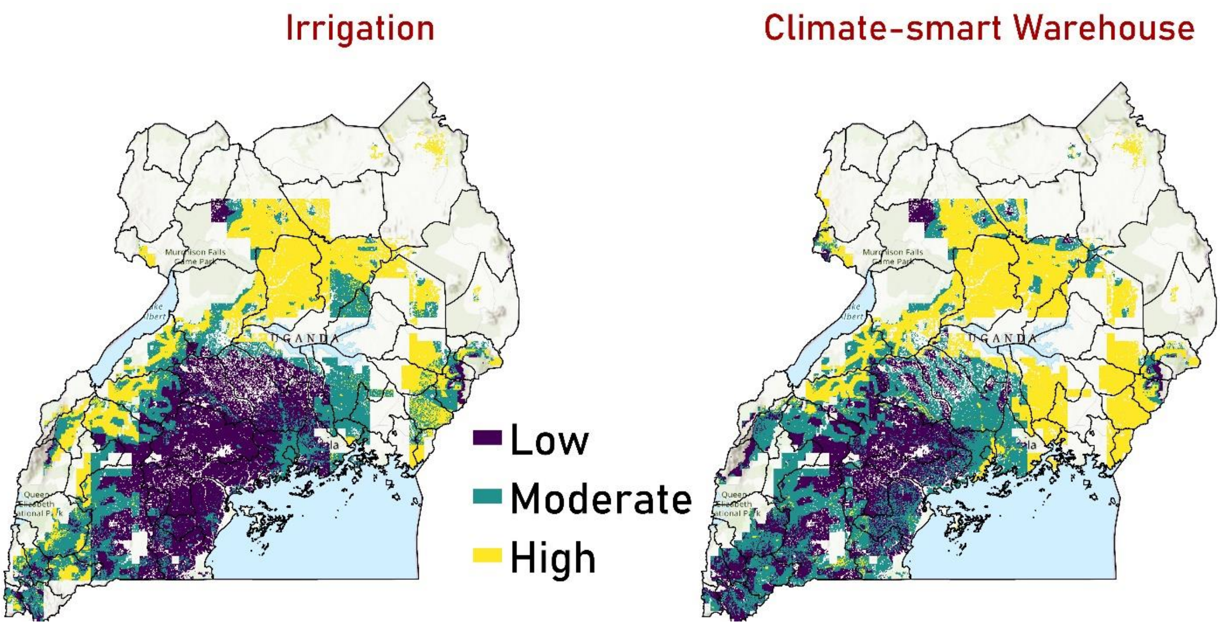

Figure 3. Comparison of the potential of two adaptation measures in potato-growing regions in Uganda under current condition

MAP INSIGHTS: WHAT CAN WE LEARN?

Potato in Tanzania

- Overall, major potato-growing regions in Tanzania have nearly equal potential for irrigation and climate-smart warehouses.
- Tabora, Shinyanga, and Simiyu regions have a higher potential for irrigation than climate-smart warehouses.
- The southern regions (Iringa, Njombe, and Mbeya) have a higher potential for climate-smart houses than irrigation.

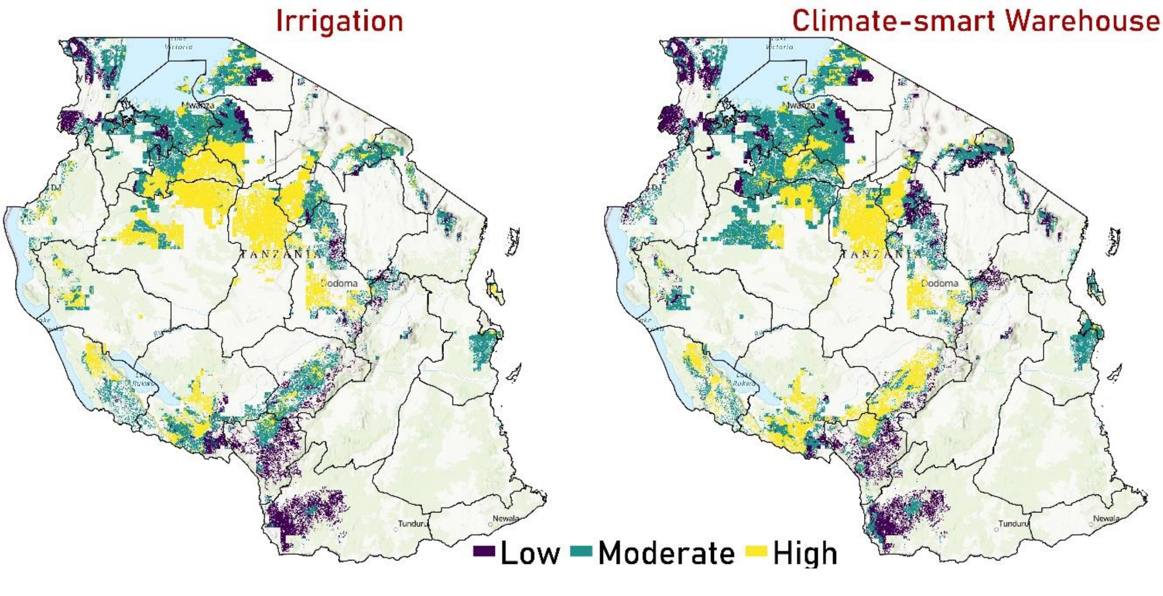

Figure 4. Comparison of the potential of two adaptation measures in potato-growing regions in Tanzania under current condit

CONCLUSIONS

- In conclusion, APM is an asset for assessing the capacity and potential of specific adaptation measures to a particular system, community, or region to adapt to environmental or socioeconomic changes.

- By analyzing various factors such as land use/cover resources, infrastructure, social dynamics, and governance, adaptation potential mapping provides a comprehensive understanding of the strengths and vulnerabilities of a system in the face of challenges.

- Through the process of APM, decision-makers and stakeholders can identify areas of high potential for successful adaptation and prioritize resources and efforts accordingly. This approach helps develop effective strategies and policies for managing and mitigating climate change, natural disasters, or other disruptive events.

- Furthermore, APM can contribute to building resilience in vulnerable communities and enhancing their adaptive capacity. Identifying key assets, strengths, and opportunities makes it possible to mobilize resources, promote sustainable practices, and foster community engagement.

APPENDIX

Crop Growth Suitability

Crop growth suitability map derived from climate, agronomic properties, soil properties, and socioeconomic conditions via machine learning approach (Confidence, Duku, 2023).

Photovoltaic Power Potential (PVOUT):

Developed by SOLARGIS (https://solargis.com) and provided by the Global Solar Atlas (GSA), this data resource contains photovoltaic power potential (PVOUT) in kWh/kWp covering the globe. Data is provided in a geographic spatial reference (EPSG:4326). The PV power output (PVOUT), defined as the specific yield, illustrates this potential. PVOUT represents the amount of power generated per unit of the installed PV capacity over the long term, and it is measured in kilowatt-hours per installed kilowatt-peak of the system capacity (kWh/kWp). PVOUT is a significant factor in the energy supply for climate-smart warehousing systems. Higher energy capacity is high in potential, and lower energy capacity has been classified as low in potential.

Global Gridded Relative Deprivation Index (GRDI)

The Global Gridded Relative Deprivation Index (GRDI), Version 1 (GRDIv1) data set characterizes the relative levels of multidimensional deprivation and poverty in each 30 arc-second (~1 km) pixel, where a value of 100 represents the highest level of deprivation and a value of 0 the lowest. GRDIv1 is built from sociodemographic and satellite data inputs that were spatially harmonized, indexed and weighted into six main components to produce the final index raster. Inputs were selected from the

APPENDIX

best-available data that either continuously varies across space or has at least administrative level 1 (provincial/state) resolution and has global spatial coverage. GRDI has been considered for classifying the purchasing power of individuals for climate-smart warehousing. Higher values have been classified as low potential, and lower values have been classified as high potential.

Wind Power Density

Wind Power Density (WPD) is a quantitative measure of wind energy available at any location. It is the mean annual power available per square meter of the swept area of a turbine and is calculated for different heights above ground. Calculation of wind power density includes the effect of wind velocity and air density.Wind Power Density is a significant factor in the energy supply for climate-smart warehousing systems. A higher density is high in potential, and a lower density has been classified as low in potential.

Distance to the nearest city (Accessibility)

Accessibility is defined as the travel time to a location of interest using land (road/off-road) or water (navigable river, lake, and ocean) based travel. This accessibility is computed using a cost-distance algorithm which computes the "cost" of traveling between two locations on a regular raster grid. Generally, this cost is measured in units of time. The cells in this raster grid contain values that represent the cost required to travel across them. Hence this raster grid is often termed a friction surface. Accessibility is much needed in transporting goods to the warehouse, infrastructure facilities, and market.

APPENDIX

Elevation (GTOPO30)

GTOPO30 is a global digital elevation model (DEM). Elevations in GTOPO30 are regularly spaced at 30-arc seconds (approximately 1 kilometer). GTOPO30 was developed to meet the needs of the geospatial data user community for regional and continental scale topographic data.The elevation is crucial to construct a climate-smart warehouse or transporting goods to the warehouse. In this assessment, Higher elevations are classified as lower potential, and lower elevations are classified as a higher potential.

HydroBASINS

Distance from the location to the next downstream sink along the river network, in kilometers. This distance is measured to the next downstream endorheic sink (if there is one) or (if there is none) to the most downstream sink (i.e., the ocean). Distance to the river stream is crucial to implement irrigation infrastructure. In our assessment, minimal distance has been considered a higher potential to implement irrigation, and maximum distance has been considered as a lower potential.

Factors	Inputs to derive factors
Crop Growth Suitability	Climate, Soil, Agronomic practices, and socioeconomic variables

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Photovoltaic Electricity Potential	aerosol data set, Water vapor, Ozone, and irradiance
Relative Deprivation Index	Sociodemographic datasets from satellite remote sensing
Wind Power Density	Topography, Orography, Land use to roughness length, and Bathymetry
Distance to major cities	Road network, Railway network, Navigable rivers, Major waterbodies, shipping lanesShipping lanes, LULC, and Elevation
Elevation	Altimeters measurements
HydroBASINS	Elevation, River stream orders
Freshwater Availability	Groundwater, soil moisture, snow and ice, surface waters, and wet biomass